Performance Based Brake Tests (PBBT)

Considering Air Brake Adjustment Analysis, Weight & Push Rod Stroke Relative to Predicting Brake Force in Collision Reconstruction

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July 2003

Abstract

For approximately 10 years USDOT/NHTSA, USDOT/FHWA/ Office of Motor Carriers (now the FMCSA) and the CVSA (Commercial Vehicle Safety Alliance) studied and tested PBBT's for law enforcement use.

Effective February 9, 2003 the Federal Motor Carrier Safety Administration (FMCSA) recognized the use of certain approved Performance Based Brake Testers (PBBT) for the enforcement of minimum brake force performance as prescribed by 49 CFR §393.52 of the Federal Motor Carrier Safety Regulations (FMCSR).

"Round Robin" tests conducted and supervised by NHTSA of PBBT's acknowledged the benefits to safety by enforcement to better identify vehicles operating with deficient or defective brakes but also the potential use in collision analysis and research.

This paper discusses testing of instrumented Commercial Motor Vehicles (CMV) to monitor push rod strokes, weight, brake force (measured by the PBBT) in real time compared to emergency braking with the same CMV under test track conditions. Participating and peer review of this testing was conducted at the South Carolina Accident Reconstruction Specialists (SCARS) conference June 2002 and the International Association of Accident Reconstruction Specialists (IAARS) July 2003.

What is a PBBT?

"A PBBT is a device that assesses the braking capability of a vehicle through quantitative measure of individual wheel brake forces or overall vehicle brake performance in a controlled test. They are widely used for brake inspection in Europe and Australia and are beginning to emerge as both an enforcement tool and diagnostic aid for private sector and repair shops."[1]

PBBTs are available in permanent ground mounted units as well as trailer mounted portable units. The PBBT can be used to analyze collision vehicles provided the brake system can be activated and the subject vehicle has inflated tires with wheels attached or can be replaced to conduct the testing.

Testing was conducted with an FMCSA approved BM Autoteknik Model 20200 PBBT sold and serviced by RAI (Radlinski & Associates) of East Liberty, Ohio.

[1] Performance-Based Brake Testers – Round Robin Study; Federal Motor Carrier Safety Administration; 11/2000; Publication No. FMCSA-MCRT-01-02

Brake Analyst (Push Rod Stroke Potentiometer – String Gauge)

The Brake Analyst utilizes ten (10) potentiometer / string gauges that are attached to each air brake chamber and the push rod. The test unit is then interconnected with an air pressure application sensor. This test instrument allows a very accurate measurement of air brake push rod stroke relative to time and pressure. In addition to push rod stroke, the instrument can help identify foundation brake defects to include cracked drums, worn cam bushings, weak return springs, slow air brake valves and out of round drums. [2]

Maximum Braking Tests

After testing the truck tractor and semi trailer on the PBBT maximum braking tests were conducted on a dry blacktop surface with a measured friction value of 0.77g to 0.80g.

Speed was measured with a Stalker ATS® (Acceleration Tracking System) RADAR with data acquisition and recording capability. This unit calculates speed, +/- acceleration and distance of a moving object.[3]

The hard brake decelerations were also found to leave observable tire marks which were recorded with total station forensic mapping technology.

[2] Brake Analyzer – Manufactured and operated by Phil Smith of Grand Junction, CO
Phone 970-260-8461

[3] STALKER ATS RADAR, www.stalkerradar.com

Methodology

Testing was conducted by analyzing the subject vehicle for predicted brake force while monitoring push rod stroke relative to application pressure at various brake adjustment levels utilizing the PBBT and the Brake Analyst. The predicted values were then compared to actual emergency, full brake applications with the same vehicle.

A second series of tests were conducted to evaluate potential problems common to portable PBBTs when testing tandem axles. Testing conducted by the FMCSA established a potential for incorrect weight calculations when tandem axles (typically within 4 to 4.5 feet of one another) when one axle of the tandem is lifted in the test rollers while the adjacent axle is at or near ground level.

Drive on ramp extensions can be used to keep the tandem axles level during PBBT testing. These are not necessary for permanent in-ground units. Tests were conducted with and without the extension ramps.

Test Vehicle:

Freightliner Model FLD Conventional
VIN 1FUYDCYB1UL805728
Date of Manufacture 03/97
Axle 1 – Type 20 air chambers MGM
5.5” Meritor/Rockwell ASA
Leaf spring axle
19.5” Rolling radius tire
15.0” brake drums
Axle 2 - Type 30 air chambers MGM
5.0” Meritor/Rockwell ASA
19” Rolling radius tire
16.5” brake drums
Axle 3 – Type 30/30 air chambers MGM

5.0” Meritor/Rockwell ASA
19” Rolling radius tire
16.5” brake drums
WABCO ABS sensors - Axle 1 & 3
Air ride tandem suspension

Great Dane 48 foot van semi trailer
VIN 1GRAA9628YB028830
Date of Manufacture 08/99
All four brakes:
Type 30/30 air chambers MGM
5.5” Meritor/Rockwell ASA
20” Rolling radius tire
16.5” brake drums
3 leaf suspension

PBBT Extension Ramps

Tests conducted without the use of extension ramps resulted in lower than actual axle weight on the **tandems** and a lower overall vehicle weight. The PBBT calculates brake force relative to weight.

Total Brake Force / Total Weight = g

As a result of the lower calculated weight, the estimated g force was unrealistically high and inconsistent with the subsequent emergency brake tests. Calculated predicted g force was 0.72g to 0.82g ***without*** the extension ramps.

The combined weight of the truck tractor and semi trailer was measured at 27,300 pounds without the use of the extension ramps and 30, 900 to 31,000 pounds with the use of extension ramps.

With the use of the extension ramps the average brake force / weight was calculated at 0.58g to 0.61g with all brakes in adjustment.

Previous tests revealed no significant inconsistencies when testing 2 axle vehicles ***without*** the extension ramps.

Comparison PBBT to Emergency Brake Test results.

Tests conducted with all brakes adjusted at push rod strokes of 1.4 to 1.6 inches were found to be quite consistent with the PBBT predicted values. These tests were conducted at speeds from 40.7 MPH to 48.0 MPH.

The PBBT predicted brake force values of 0.59g to 0.61g with all brakes adjusted. The measured comparison maximum braking tests resulted in 0.58g to 0.59g decelerations.

Two brakes were then taken out of adjustment, one on the truck tractor drive wheels and one on the semi trailer. The PBBT predicted 0.50g to 0.51g. The measured maximum braking test resulted in a deceleration of 0.54g. It was noted that the truck tractor’s brake that had been taken out of adjustment had begun to provide minimum shoe to drum contact. This was the result of the automatic brake slack adjuster beginning to bring the brakes back in to adjustment during the series of PBBT tests and moving the vehicle to the test area. This accounted for the slightly higher value than the predicted PBBT brake force value.

Emergency Brakes Only

Three tests were conducted bringing the truck tractor and semi trailer to approximately 45 MPH and applying the emergency brakes only and allowing the vehicle to come to a complete stop. These were compared to the PBBT emergency/parking brake force predicted values.

The full emergency brake application (truck tractor and semi trailer) caused the vehicle to stop with 0.22g to 0.25g. PBBT predicted parking brake force was 0.30g.

Utilizing the trailer emergency brake only resulted in a measured 0.16g with a PBBT predicted parking brake force of 0.20g.

SCARS 2002 tests

PBBT vs. maximum braking tests were conducted at the South Carolina Associations of Reconstruction Specialist, June 2002. Those tests involved the use of a 2001 Volvo V70 truck tractor and 1998 Wabash van semi trailer both equipped with ABS brakes.

The PBBT predicted value was 0.63g with the measured maximum braking of 0.58g – 0.60g.

Summary

- **The predicted PBBT brake force values consistently were found to fall within 0.05g of the measured, tested values on service brake tests.**
- **A typical variance of 0.05g but up to 0.08g has been found when compared to Emergency Brake only tests.**
- **Predicted values were typically slightly higher than the measured tested values.**
- **The slightly higher PBBT predicted value was expected as the PBBT is a low speed test compared to higher speed testing.**
- **It was found extension ramps were important to accurate weight calculations on a portable unit. This was expected as this issue was addressed in the FMCSA "Round Robin Tests"**
- **IAARS observers were able to measure visible tire marks even though the vehicle was equipped with ABS brakes on the truck tractor and semi trailer.**
- **The PBBT test values would be of value in an accident reconstruction analysis and should be explored as another data gathering tool.**
- **Many states are considering use of PBBTs for Commercial Motor Vehicle enforcement. Collision reconstruction officers should explore the use of these devices for investigation purposes.**
- **PBBT tests are not limited to air braked vehicles. Hydraulic braked trucks and passenger cars can be tested by the use of these devices.**
- **Some PBBTs only measure minimum brake performance levels but do not quantify brake force. If purchase of a PBBT is being considered a unit that quantifies brake force would be much more useful for collision reconstruction analysis.**